Open Graded Friction Course Stormwater Treatment BMP

Design Guidance

May 2019

California Department of Transportation
HQ Division of Design

Introduction

The purpose of this guidance is to help districts designers use Open Graded Friction Course (OGFC) as a Stormwater Treatment Best Management Practice (TBMP). This guidance gives background on its current use, appropriate siting criteria, and maintenance developed by Caltrans Division of Maintenance, Office of Pavements Engineering. The referenced guides include what type of asphalt concrete to specify in coordination with Maintenance and Pavements. This guide includes: example plans, item number, specifications, costs, how to balance competing goals, draft text for environmental document, and the methodology for documenting NPDES permit compliance in SWDR.

Background

OGFC has been used as an effective paving material for various reasons, including the reduction of noise and to reduce tire spray from rainfall on the highway surface for better visibility during rain events. OGFC is also referred to as Open Graded Asphalt Concrete (OGAC) in some studies (Caltrans Maintenance Technical Advisory Guide, 2003). Further studies from other DOTs, have shown significant reduction in pollutants from OGFC pavements, compared to traditional highway pavements (dense graded asphalt concrete or Portland cement concrete surfaces (ASCE 2012) and (Caltrans 2011). The pollutant load reduction from OGFC lanes in comparison to traditional pavement runoff characterization for pollutants, would suggest that that they are as effective at pollutant removal as many of the treatment BMPs in the Caltrans approved list. Caltrans already uses OGFC for noise and spray reduction, so using for the added benefit of water quality improvement is a sustainable way to provide pollutant removal and treatment of storm water runoff.

Limitations

When considering the OGFC as a SW treatment there should be caution in using other materials, such as rubberized OGFC (RHMA-O or RHMA-G), as this would fill the voids in the pavement and prevent the water from filtering through the layer and then not reduce the spray on vehicles undercarriages. If crumb rubber is added to the OGFC layer, the water quality benefits no longer exist, due to the voids being filled with crumb rubber, and therefore reducing the permeability and void space that provides the treatment. “The Project found no water quality benefit at any of the California sites where the overlay contained recycled rubber. This may be the result of insufficient permeability resulting from the use of larger amounts of rubberized binder” (Caltrans 2012). The Caltrans specification higher percentage of crumb rubber from Texas DOT, likely causes the reduced permeability and effectiveness. For this reason, rubberized AC is not recommended for use as a Stormwater treatment

Caltrans has commitments to use recycled tires in asphalt concrete by CA legislation, AB 338, and CA public resource 42703. This requirement is for state wide use of recycle rubber and not a per project basis. Caltrans also has requirements for complying with NPDES permit post construction and TMDL compliance units, compliance units are also on a statewide basis and not per project requirement. These two environmental commitments are competing in nature, due to rubberized AC not working as a treatment BMP, so each district must balance these competing goals based on their current targets for compliance.

Siting Criteria

Appropriate locations for OGFC as a treatment BMP include the following:

1. Lower elevation highways where traction sand is not applied, and freezing temperatures are rare, usually below 3,000 ft elevation.
2. Highway traveled way sections that do not receive runoff from cut sections, diked cut sections at super elevation with gutter drainage are ok. Avoid areas with sheet flow across lanes from sediment areas.
3. Highway traveled way sections that do not receive offsite sediment laden storm water flows.
4. Drainage areas that are entirely made up of impervious surfaces.
5. Any paved area except as described in the Caltrans Open Graded Friction Course Usage Guide, February 2006.
6. When crumb rubber is not added to the OGFC layer.
7. When Infiltration BMPs are not feasible.
8. Highway with greater than 50 MPH speed limits. The higher speeds help to keep the voids open for permeability. Lower speed highways may claim credits for OGFC as a treatment BMP if they provide general maintenance. General maintenance: "Water hoses, high pressure cleaners, and specialized cleaning vehicles may be used for this purpose." (MTAG 10-15).

Design Criteria: The project engineer must consult with the OGFC Usage Guidance and the district pavement office to determine if OGFC is appropriate for the location under consideration. Discussion with the Traffic Operations may also be needed to consider safety factors such as ponding, icing, or unraveling. Concurrence of the pavements office should be documented in the SWDR. If the location is appropriate, then an open graded mix may be included in the plans and specification package and credit may be taken for storm water treatment. This could be used for post construction, redevelopment, alternative compliance, and potentially Compliance Unit TMDL credits. More detailed siting criteria can be found on the OGFC usage guide and maintenance manuals referenced.

http://www.dot.ca.gov/hq/esc/Translab/ormt/pdf/FrictionCourseGuide.pdf

Maintenance

Maintenance interval: Same as OGFC used for other purposes, see Caltrans OGFC Usage Guidance, February 2006, page section 4.0 Maintenance. Maintenance of OGFC overlays includes removal and replacement of the failed or aged OGFC section. Maintenance division does not recommend any other treatment methods currently. For the special case of highways under 50 MPH, claiming OGFC as a treatment BMP, follow the MTAG 2007 criteria for some areas with permeability issues. Additional maintenance guidance can be found in the Caltrans Maintenance Manual Volume 1, Chapter A on flexible pavements, which includes OGFC. Maintenance activities on roadways surfaced with OGFC should avoid obstructing the lateral flow of water through the OGFC. These activities may include crack sealing or patching a small failed area with DGAG, thus creating a dam where water may be retained or

stored and contribute to further failure of the OGFC surfacing. When large areas of patching are involved, OGFC should be replaced with OGFC (OGFC Usage Guide, Section 4.0).

Treatment BMP Selection

OGFC would be considered a flow through treatment device as it would not infiltrate water, though some water would be captured in the OGFC voids. The NPDES Permit requires infiltration as the treatment mechanism of first priority. For this reason, designers should first use the Caltrans PPDG T-1 checklist for the appropriate BMP consideration. If these BMPs are not feasible, OGFC can provide treatment from the highway runoff and meet the NPDES permit requirements for maximum extent practicable, as an approved treatment BMP. For OGFC use on a highway, it is recommended that the traveled way and the shoulder be paved (HDM 630). Paving the shoulder and roadway increases the treatment area.

Treatment Calculation

The treatment area is the surface area of the OGFC.

- 1 acre of OGFC = 1 acre of treatment of Caltrans Highway Storm Water

Or another way to describe is treatment is:

- Post Construction Treatment Area = New Impervious Surface- OGFC
- 1 acre of OGFC = 1 TMDL Compliance unit

OGFC pollutant removal treatment mechanism is filtration through the void space of the PFC layer and reduction of water splashing on the vehicle undercarriage. Treatment removal is equal to or superior to many flow through devices such as, bio-retention. A portion of the calculated treatment can be attributed to the reduction of water splashed up from the pavement and to the under body of vehicles in sections of OGFC.

Pollutant Removal Efficiency

Constituent pollutant removal efficiencies from typical OGFC application for Texas and North Carolina highways was sampled and studied. The monitoring results are presented below. “Monitoring before and after the replacement showed that mean Total Suspended Solids (TSS) levels dropped from 46 mg/L to 8:7 mg/L, an 81% difference. Concentrations of total metals also decreased: lead (Pb) by 78%, cadmium (Cd) by 69%, zinc (Zn) by 66%, and copper (Cu) by 35%. Some dissolved metals (Zn and Cd) declined by about 60%. (ASCE 2012)”. Caltrans water quality monitoring showed similar results and demonstrated that the Caltrans OGFC section 39 specification for California highways was an effective BMP (CT 2012).

Specifications

In general, OGFC will follow the 2018 Standard Specification and section 39-2.04 Open Graded Friction Course. OGFC designs will include asphalt binders and materials gradation, these should follow the Highway Design Manual, Caltrans Open Graded Friction siting criteria guidance, or Maintenance Technical Advisory Guide (MTAG), based on the project siting information. Additionally, these should be coordinated with the district pavement engineer for recommendations on the appropriate applications for the highway section. The water quality studies from Caltrans and other DOTs showed that OGFC layers of 1-2 inches are appropriate thickness for effective treatment BMP applications.

Comparison of material specifications shows the gradations and materials for Caltrans OGFC are similar to the Texas DOT materials, so the water quality studies can be correlated to Caltrans projects (ASCE 2012)(Caltrans 2012).

Standard Specification 2018, Section 39-2.04 OGFC corresponds to The Hot Mix Asphalt Open Graded (HMA-O, Open Graded Friction Course) item number: 390401.

Costs

Pavement costs vary with location and quantity. Check the latest bid prices for OGFC for your projects using the District 8 cost data base for closest project location. Follow the OGFC usage guidance and coordinate with your local pavements engineer for appropriate gradations and binders. 2015-2016 costs ranged from $110.0-$522.0 /ton, with an average escalated cost of $222.00/ton.

Item No	Item Description	Unit Pay	2015 Section
390401	HOT MIX ASPHALT-OPEN GRADED (OPEN GRADED FRICTION COURSE)	TON	39

OGFC Example Design Information

Example Water Quality Assessment

Text for environmental document (PEAR, PID, and/or Project Report)

Caltrans projects are required to comply with the federal Clean Water Act section 402, Porter-Cologne, Water Quality Control Act, Water Code Division 7 and Related Sections (As amended, including Statutes 2018). These are incorporated in the Caltrans NPDES permit and SWMP requirements. Appendix IV of the NPDES permit includes requirements for complying with statewide Total Maximum Daily Loads (TMDLs) by achieving compliance units (CU). Caltrans has a yearly goal of 1650 CU. Caltrans is also required to comply with CA AB 383 and the California Public Resources Code 42703, which has goals for use of crumb rubber in Caltrans pavement. Caltrans project delivery memo's, design information bulletins, and guidance recognize the importance of complying with both competing requirements and allows flexibility in how the department complies per project, with the overall statewide goal for both as the target metric for compliance.

Example per project: Caltrans is required to comply with NPDES permit Appendix IV to achieve compliance units and post construction treatment, using approved stormwater treatment BMPs to the maximum extent practicable. The public resource code and Caltrans project delivery memos allow environmental requirement justification to not use crumb rubber in all asphalt applications for highway rehabilitation and maintenance. Compliance with the Caltrans NPDES permit, CWA, and CA Porter-Cologne (Water Quality Control Act), are valid justification to not use crumb rubber RHMA-O on a project, so the OGFC can function as a treatment BMP (Caltrans HDM 630).

Caltrans must meet both competing target goals, so the district pavements/maintenance engineer and the district NPDES staff was consulted and this project was approved for OGFC use, and the district is on track to meet both the recycled rubber and TMDL compliance unit goals. The district pavements engineer and NPDES coordinator will continue to track the target goals and decide when each is warranted.

Example SWDR text

The use of OGFC as treatment must be coordinated with a variety of Caltrans offices, to assure all of requirements are met. Project engineers may use this example text to help streamline documentation of the design coordination and decisions.

Example SWDR text: Modify for your projects unique design parameters.

This project considered infiltration treatment BMPs in accordance with the NPDES permit post construction requirements and it was determined they were infeasible due to the lack of right of way sufficient to infiltrate the water quality volume (edit per site conditions). The project location met the siting criteria based on the Caltrans, Open Graded Friction Course Usage Guidance, February 2006. The project engineer coordinated with the district pavements/maintenance engineer and determined the district is forecast to meet the recycled crumb rubber goals. Therefore, use of OGFC as treatment BMP is appropriate and will meet the post construction requirements. The project is located in a sediment TMDL watershed, where Caltrans is listed as a stakeholder. Use of OGFC will allow the district to create 2 compliance units in addition to the post construction treatment.

Calculations

Measure all the surface area of the OGFC using micro station from surfaces areas (layout sheets or typical lengths and cross sections as appropriate). Then multiply by the depth for the volumetric quantity of HMA-O. Multiply the density by the volume and convert for the tonnage of HMA-O for quantity sheet in TON of material, which follows the item code above and standard specifications39-2.04.

Density of HMA-O typical = 150 lb/ft^3

Typical HMA-O layer is 0.1 ft or 1.2”

Area(ft^2) x Depth (ft) x Density (lb/ft^3)x 1 TON/2,000.0 lb = TON

As shown above the area treated or TMDL CU in acres is the direct measurement of the surface areas of the OGFC. The HMA-O pavement surface area should be shown as a separate column with (N) designation for information only, shown as acres of treatment area, so they can be used by NPDES for tracking compliance unit or treat area compliance. This information is required for tracking the Stormwater Data report and for transfer to maintenance for tracking. TBMP for NPDES compliance.

Photo Example of OGFC o

Water draining through OGFC layer to the shoulder

Example Plan Sheets (Layout, Cross section, and Quantity Summary)

Sheets L-1, X-1, and Q-1

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
				4	111

DATE

6-11-18
PLANS APPROVAL DATE

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REGISTERED PROFESSIONAL ENGINEER — No. — Exp. — CIVIL — STATE OF CALIFORNIA

NOTE:

FOR ACCURATE RIGHT OF WAY DATA, CONTACT RIGHT OF WAY ENGINEERING AT THE DISTRICT OFFICE.

BASIS OF BEARINGS:

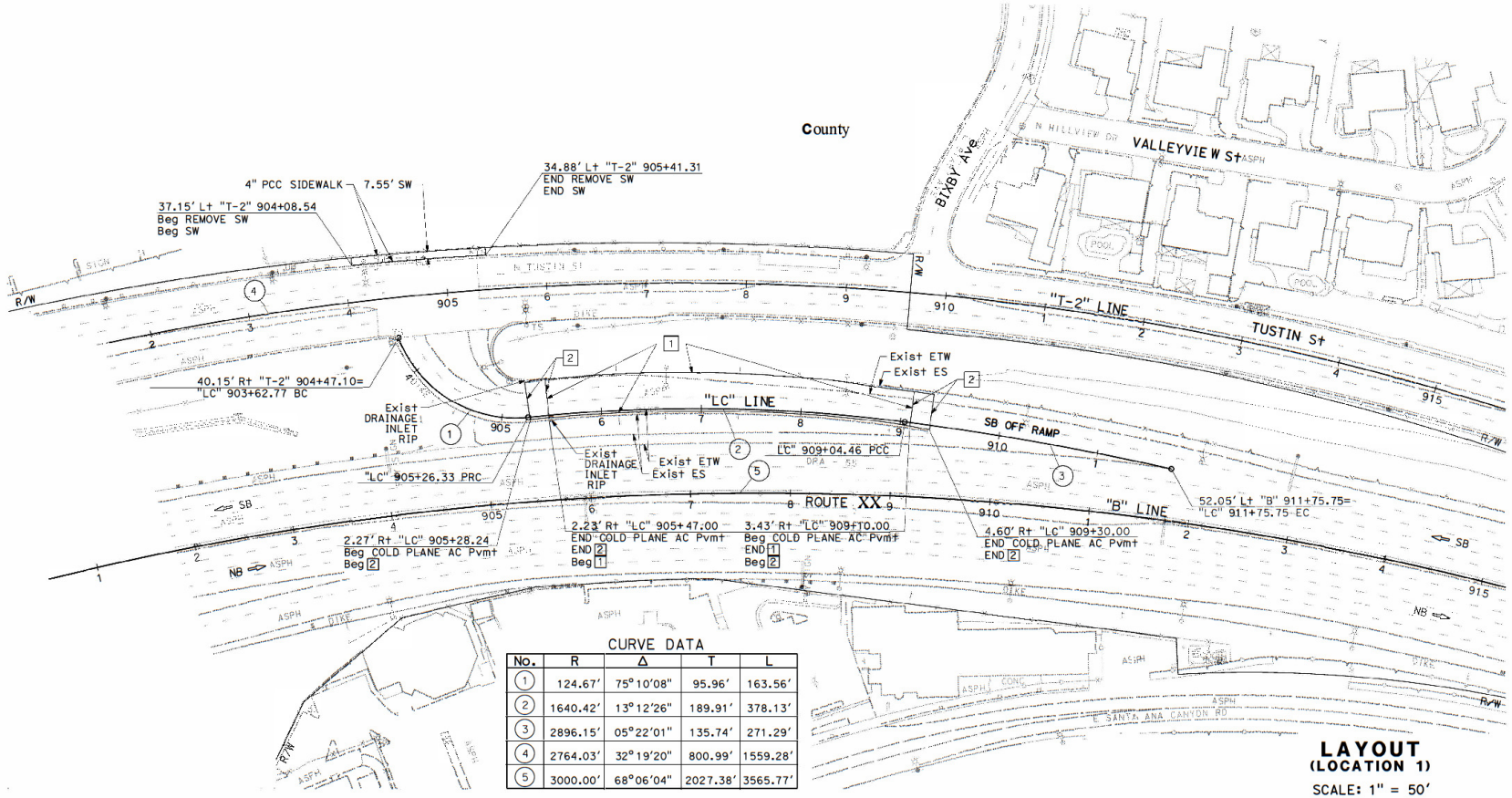
THE BASIS OF BEARINGS FOR THIS SURVEY IS THE CALIFORNIA COORDINATE SYSTEM, ZONE VI, NAD 83 (EPOCH 1991.35)

LEGEND:

- [X] PAVEMENT STRUCTURAL SECTION TYPE, SEE SHEET X-1.
- (X) CURVE No.
- ⇨ DIRECTION OF TRAFFIC

ABBREVIATIONS:

AITS	ALTERNATIVE IN-LINE TERMINAL SYSTEM
COA	CITY OF ANAHEIM
COO	CITY OF ORANGE
C&G	CURB & GUTTER
EAA	END ANCHOR ASSEMBLY
RIP	REMAIN IN PLACE



CURVE DATA

No.	R	Δ	T	L
(1)	124.67'	75°10'08"	95.96'	163.56'
(2)	1640.42'	13°12'26"	189.91'	378.13'
(3)	2896.15'	05°22'01"	135.74'	271.29'
(4)	2764.03'	32°19'20"	800.99'	1559.28'
(5)	3000.00'	68°06'04"	2027.38'	3565.77'

LAYOUT
(LOCATION 1)

SCALE: 1" = 50'

L-1

REVISED BY | DATE REVISED | CALCULATED-DESIGNED BY | CHECKED BY | FUNCTIONAL SUPERVISOR

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans

LAST REVISION 00-00-00 | DATE PLOTTED => 12-JAN-2018 | TIME PLOTTED => 09:51

BORDER LAST REVISED 7/2/2010 | USERNAME => | DGN FILE => ea.dgn | RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3 | UNIT 3000 | PROJECT NUMBER & PHASE

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
				2	111

PLANS APPROVED No. 61

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CIVIL

STATE OF CALIFORNIA

NOTES:

1. DIMENSIONS OF THE PAVEMENT (STRUCTURAL SECTIONS) ARE SUBJECT TO TOLERANCES SPECIFIED IN THE STANDARD SPECIFICATIONS.
2. GORE AREAS AND SUPERELEVATION TRANSITIONS ARE NOT SHOWN BY TYPICAL SECTIONS.
3. EXACT LOCATIONS AND TYPES OF HMA DIKE, CURB, GUARD RAILING, AND CONCRETE BARRIER ARE SHOWN ON THE LAYOUTS, CONSTRUCTION DETAILS AND SUMMARY OF QUANTITIES SHEETS.
4. SEE CONSTRUCTION DETAIL SHEET (C-6) FOR STRUCTURAL SECTION TYPE [4]
5. SEE CONSTRUCTION DETAIL SHEETS (C-1, C-2 & C-5) FOR COLD PLANE AND OVERLAY DETAIL.
6. SEE CONSTRUCTION DETAIL SHEET (C-2) FOR OVERLAY DETAILS AT INSIDE AND OUTSIDE SHOULDER AND AT SHOULDER AROUND INLET

ABBREVIATION:

RIP REMAIN IN PLACE

PAVEMENT CLIMATE REGION

SOUTH COAST

TYPICAL PAVEMENT STRUCTURE SECTIONS

[1] 0.10' HMA-OGFC (OPEN GRADED FRICTION COURSE)

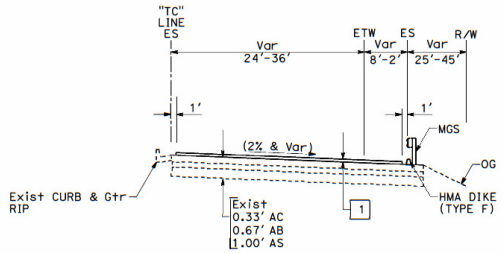
[2] 0.10' & Var COLD PLANE AC Pvmt
0.10' & Var HMA-OGFC

[3] 0.10' & Var COLD PLANE AC Pvmt
0.10' & Var HMA (TYPE A)

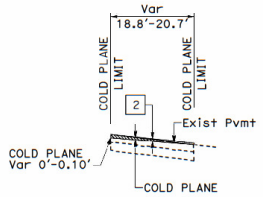
[4] 0.50' HMA (TYPE A)

LEGEND:

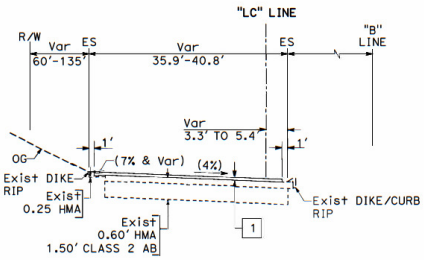
[X] PAVEMENT STRUCTURAL SECTION NO.



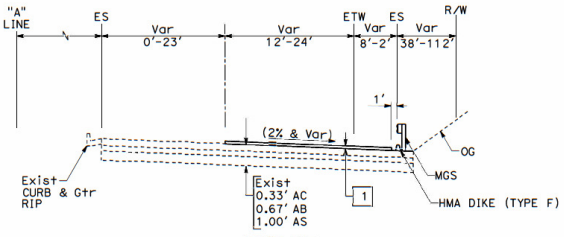
"TC" LINE
Sta 91+38.74 TO Sta 98+13.75



DETAIL A
"LC" 905+28.24 TO "LC" 905+47.00
"LC" 909+10.00 TO "LC" 909+30.00
"TC" 82+80.00 TO "TC" 83+00.00
"TC" 98+13.75 TO "TC" 98+34.41



"LC" LINE
Sta 905+28.00 TO Sta 909+30.00



"TC" LINE
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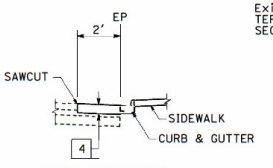
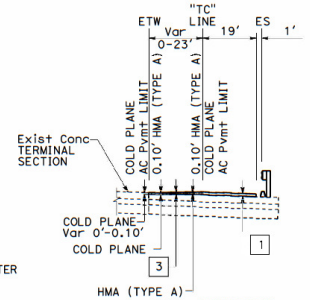


EDGE CONDITION
"T" 40+62.16 TO "T" 40+80.98



EDGE CONDITION
"TC" 82+80.00 TO "TC" 85+49.50

SR- SB OFF RAMP **SR- EB Ave OFF RAMP**

TYPICAL CROSS SECTIONS
(LOCATIONS 1 AND 2)

NO SCALE

X-1

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans

REVISED BY	DATE REVISED

CALCULATED-DESIGNED BY T
CHECKED BY
FIL T.OCAL SUPERVISOR

LAST REVISION 00-00-00
DATE PLOTTED => 25-JUL-2018
TIME PLOTTED => 10:19

BORDER LAST REVISED 7/2/2010

RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

UNIT 3000

PROJECT NUMBER & PHASE

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET TOTAL No. SHEETS
XX	XX	XX	7.2, 8.2	XX XX

REGISTERED CIVIL ENGINEER — XX-X-XX DATE

6-11-18
PLANS APPROVAL DATE

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ROADWAY QUANTITIES

SHEET No.	DESCRIPTION	STATION LIMITS	(N) PAVEMENT SECTION TYPE	HOT MIX ASPHALT (TYPE A)	HOT MIX ASPHALT-OPEN GRADED (OGFC)	TACK COAT	COLD PLANE AC PAVEMENT	(N) TREATMENT BMP (OGFC)	CLASS 2 AGGREGATE BASE
				TON	TON	TON	SQYD	AC	CY
L-1	SB OFF-RAMP TO LINCOLN	"LC" 905+28.24 TO "LC" 905+47	2		12	0.038	82	0.017	
		"LC" 905+28.24 TO "LC" 909+30	1		185	0.626			
		"LC" 909+10 TO "LC" 909+30	2		12	0.038	82	0.017	
	"TC" GORE AREA	"TC" 82+80 TO "TC" 89+49.50	3	38		0.129	281		
L-2	SUMP AREA	"TC" 84+48 TO "TC" 84+87							5.6
	EB OFF-RAMP TO TUSTIN	"TC" 82+80 TO "TC" 83+00	2		7	0.020	45	0.009	
		"TC" 82+80 TO "TC" 91+50	1		269	0.913			
L-3	EB OFF-RAMP TO TUSTIN	"TC" 91+50 TO "TC" 98+14	1		374	1.266			
		"TC" 98+14 TO "TC" 98+34	2		12	0.038	82	0.017	
C-5	TUSTIN Ave	"T" 40+62.14 TO "T" 40+81	4	2		0.002			
SHEET TOTAL				40	87	3.070	572	0.06	5.6
TOTAL FROM PLACE HMA TABLE, SHEET Q-1				7.8					
GRAND TOTAL				47.8	87	3.070	572	0.06	5.6

(N) NOT A SEPARATE PAY ITEM, FOR INFORMATION ONLY

PRE/POST CONSTRUCTION SURVEY

SHEET No.	LOCATION	STATION LIMITS	CURB RAMP	NUMBER OF CONSTRUCTION SURVEYS
				EA
C-5	EB OFF-RAMP TO TUSTIN	40+74.15	CURB RAMP	1
C-6	TUSTIN Ave	40+70	CASE A RAMP	1
			TOTAL	2

SUMMARY OF QUANTITIES

Q-1

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans
CONSULTANT FUNCTIONAL SUPERVISOR (AUTHORIZED REGISTERED ENGINEER) XX
CHECKED BY XX
REVISED BY
DATE REVISED

BORDER LAST REVISED 7/22/2010
USERNAME => USER
DGN FILE => BRIDGE.DGN
RELATIVE BORDER SCALE IS IN INCHES
UNIT XX
PROJECT NUMBER & PHASE XX
LAST REVISION DATE PLOTTED => 00-00-00
TIME PLOTTED => 00:00

References

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